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Ecological Succession Along Missouri River Reservoirs as it Relates to Development of Forest Environment for Recreational Use

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ECOLOGICAL SUCCESSION ALONG MISSOURI RIVER RESERVOIRS AS IT RELATES TO DEVELOPMENT OF FOREST ENVIRONMENT FOR RECREATIONAL USE

BY

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ECOLOGICAL SUCCESSION ALONG MISSOURI RIVER RESERVOIRS

AS IT RELATES TO DEVELOPMENT OF FOREST ENVIRONMENT

FOR RECREATIONAL USE

This thesis is approved as a creditable and independent investigation by a candidate for the degree, Master of Science, and is acceptable as meeting the thesis requirements for this degree, but without implying that the conclusions reached by the candidate are necessarily the conclusions of the major department.

Thesis Adviser Date

Head, Botany-Biology Department Date

ECOLOGICAL SUCCESSION ALONG MISSOURI RIVER RESERVOIRS
AS IT RELATES TO DEVELOPMENT OF FOREST ENVIRONMENT
FOR RECREATIONAL USE
Abstract

HOWARD G. CADY

This study was conducted to determine conditions under which natural tree seedlings establish adjacent to a young reservoir in a grassland biome.

Twenty-seven belt transects extending from typical prairie through the terrestrial succession zone to the shoreline were mapped along Big Bend Reservoir (Lake Sharpe) in central South Dakota. Twenty-five of the transects were located to include natural tree seedlings. The transects were grouped according to parent material, as determined from State Geological maps.

Results indicated that natural tree seedlings occurring on glacial outwash or loess are farther from the reservoir both horizontally and vertically (elevation) than those occurring on terrace alluvium or shale. The greater permeability of glacial outwash and loess was probably a large factor contributing to an environment favorable to tree growth farther from the reservoir than on the less permeable terrace alluvium or the relatively impermeable Pierre shale. Plant species showing high frequencies of association with tree seedlings were cocklebur (Xanthium italicum Moretti.), barnyardgrass (Echinochloa crusgalli [L.] Beauv.) and dock (Rumex sp. L.).

ACKNOWLEDGMENTS

I wish to express my appreciation to Dr. P.E. Collins and Dr. H.L. Hutcheson for their guidance and patience during the study and in the preparation of this manuscript. I would like to thank Dr. Everett M. White for advice in geology. I am indebted to Professor Charles A. Taylor for his help in plant identification.

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INTRODUCTION

Dams and reservoirs are not new to civilized man. The 348 foot long and 37 foot high "Dam of the Pagans" near Cairo, Egypt was built sometime between 2950 and 2750 B.C. (Smith, 1971). Historically more interest seems to have been directed toward the dams rather than their corresponding reservoirs. The first dams in North America were considered engineering accomplishments with the reservoirs being relatively unnoticed. The industrial revolution and the resulting increase in leisure time and money created new interest in reservoirs, primarily as a place for water based recreation. Research on production of game fish in reservoirs has been intensified, corresponding to increased recreational demands.

Trees, like fish, are also considered an asset to reservoir recreation (Iowa State Highway Com. 1916), particularly when they are near the shoreline and available for camping, picnicing or just as a source of shade and shelter. Reservoir managers in the eastern United States did not have to be concerned with establishing a forest environment near the shore of new reservoirs. In most cases there were trees already established (Spurr 1964).

The construction of water impoundments in the western semiarid and arid regions of the United States has created a new problem for the reservoir manager (Figure 1). Areas with less than 20 inches of precipitation annually (U.S. Dept. of Agriculture, 1941; Goor and Barney, 1968) are unlikely to have trees already established along the reservoir. The original floodplain forest is usually inundated by the

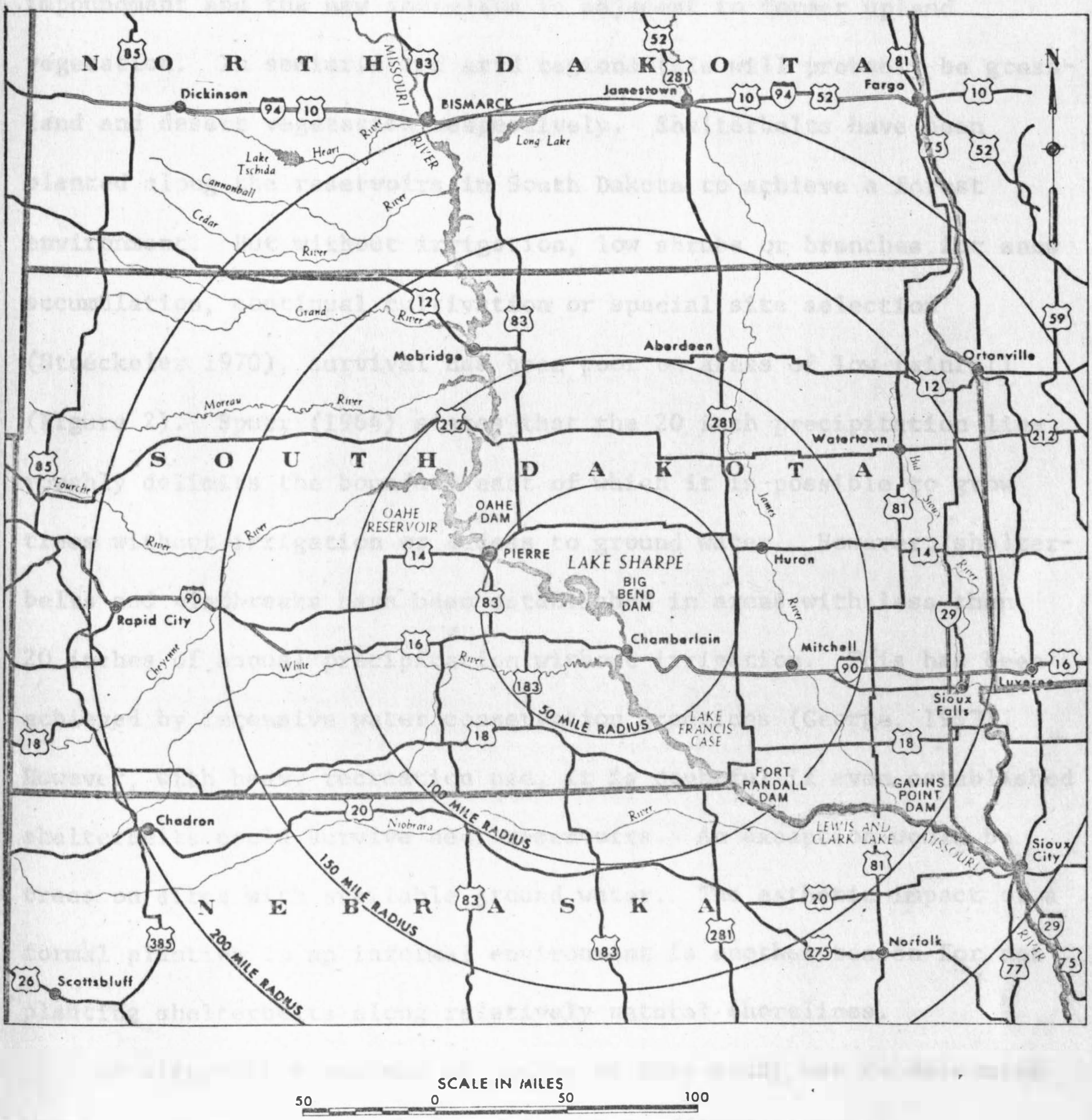


Figure 1. Location map of Big Bend Dam and Lake Sharpe.

impoundment and the new shoreline is adjacent to former upland vegetation. In semiarid and arid regions this will probably be grassland and desert vegetation, respectively. Shelterbelts have been planted along the reservoirs in South Dakota to achieve a forest environment. But without irrigation, low shrubs or branches for snow accumulation, continual cultivation or special site selection (Stoeckeler 1970), survival has been poor on areas of low rainfall (Figure 2). Spurr (1964) states that the 20 inch precipitation line roughly delimits the boundary east of which it is possible to grow trees without irrigation or access to ground water. However, shelterbelts and windbreaks have been established in areas with less than 20 inches of annual precipitation without irrigation. This has been achieved by intensive water conservation practices (George, 1953). However, with heavy recreation use, it is doubtful if even established shelterbelts could survive near reservoirs. An exception would be trees on sites with available ground water. The esthetic impact of a formal planting in an informal environment is another reason for not planting shelterbelts along relatively natural shorelines.

An alternative and the objective of this study was to determine the conditions under which natural tree seedlings were being established along a reservoir shoreline. A comparison was made between these conditions and the parent material adjacent to the reservoir. The extent of the influence of the reservoir on ground water and the corresponding favorable tree growing sites was evaluated. The feasibility of using plants showing high association with tree

Figure 2. Unsuccessful shelterbelt planting, North Shore Area, August, 1971. Elevation approx. 1450 feet.

seedlings as indicators of favorable planting sites (Chikishev, 1965) was discussed.

A literature search produced nothing that could be classified as reservoir shoreline succession. There have been numerous studies of coastal vegetation and coastline succession (Russell, 1967; Sauer, 1967; Johnson, 1919; Chapman, 1964; Bird, 1968) so background material was necessarily limited to these sources. There was one article found on phreatophytes (U.S. Dept. of Ag., 1955); however, it dealt with methods of elimination because of their high water consumption. Phreatophytes, which are basically the vegetation type concerned with in this study, are plants that extend their roots to the ground water.

The results of this study should be useful as basic ecological information on reservoir shoreline succession in a grassland biome. The correlation of tree seedling establishment and parent material may be applicable to many semiarid and arid region reservoirs. The information on favorable tree growing sites can hopefully be applied directly to South Dakota reservoirs in the effort to establish a forest environment for recreational use.

DESCRIPTION OF STUDY AREA

Lake Sharpe, or as it is commonly referred to locally, Big Bend Reservoir, was created by the construction of Big Bend Dam in 1965. The reservoir is a holding reservoir and is relatively non-fluctuating (maximum of one vertical foot) with a normal operation pool elevation of 1420 feet above sea level.

Location

Big Bend Reservoir is located on the eastern edge of the Great Plains (U.S. Dept. of Ag., 1941) in central South Dakota. It is the third reservoir, counting upstream, on the former Missouri River (Figure 1). It is located at about 100 degrees west longitude and immediately above 44 degrees north latitude.

Climate

The Yearbook of Agriculture, 1941 says of the Great Plains that "in a desert you know what to expect of the climate and plan accordingly. The same is true of the humid regions. Men have been badly fooled by the semiarid regions because they are sometimes humid, sometimes desert, and sometimes a cross between the two." With this in mind the extremes as well as the averages should be known in studying the climate of Big Bend reservoir. Records for Pierre, South Dakota which is at the upstream end of Big Bend Reservoir (Figure 1) indicate average annual precipitation to be 16.50 inches, of which 12.53 inches falls between April and September (S.D. Ag. Exp. Sta., 1971). Precipitation extremes since 1900 range from

8.85 inches in 1940 to 23.57 inches in 1915. Temperature extremes for Pierre range from a -40° F on February 2, 1905 to 115° F on July 23, 1940. Average yearly temperatures vary between 44 and 52 degrees. The climate is of a continental type with hot summers and cold winters.

Vegetation

Kuchler (1964) described the potential natural vegetation of the northern great plains, which includes the area around Big Bend reservoir (Figure 3), as wheatgrass-needlegrass (*Agropyron-Stipa*). It is moderately dense, short or medium tall grassland with western wheatgrass (*Agropyron smithii* Rydb.), bluegrama (*Bouteloua gracilis* [H.B.K.] Lag.), needle-and-thread (*Stipa comata* Trin. and Rupr.), and green needlegrass (*Stipa viridula* Trin.) comprising the dominant species. Kuchler also described a northern floodplain forest, following the Missouri river, of cottonwood (*Populus deltoides* Marsh.), Black willow (*Salix nigra* Marsh.), and American elm (*Ulmus americana* L.), but most of this forest has been inundated by the reservoir.

Topography

The most notable topographic feature of the Big Bend Reservoir area is the Missouri River trench, which is from two to four miles wide and in most places, 200 to 400 feet deep (Flint, 1955; Crandell, 1958). The topography is rolling to steep near the trench (Figure 3) and becomes rolling to flat to the northeast and southwest.

Figure 3. Typical landscape looking west from East Bend Area, August, 1971.

The Missouri River trench was formed by melt-waters originating from glaciers and roughly delineates the western extent of the glaciers. Generally the glaciated region east of the trench has a smoother topography than the nonglaciated region to the west.

Parent Material

The only bedrock that is exposed in the reservoir area is Pierre shale (Crandell, 1958). It is also the most abundant parent material particularly toward the nonglaciated west region. The Pierre shale formation is marine sediment deposited during the Late Cretaceus Age. It is about 1,000 feet thick and underlies all other parent materials in the area. The stratum of the Pierre shale that comes in contact with the reservoir is the Gregory member designated on State Geological maps as Kpg (S.D. State Geological Survey, 1950 a,b and 1951 a,b). Pierre shale is described by Flint (1955) as very easily eroded because of the large proportion of clay and the small proportion of quartz.

Parent materials of more recent origin that border the reservoir with about equal frequency to Pierre shale, are terrace alluvium, loess and glacial outwash. Terrace alluvium is material that has been redeposited by water from upslope. The material encountered in this study was on the nonglaciated west side of the reservoir covering the Lower Brule and Narrows Area (Figure 4). Originating from Pierre shale the terrace alluvium in these areas is largely reworked shale. The State Geological Surveys codeletters for terrace alluvium are Qta.

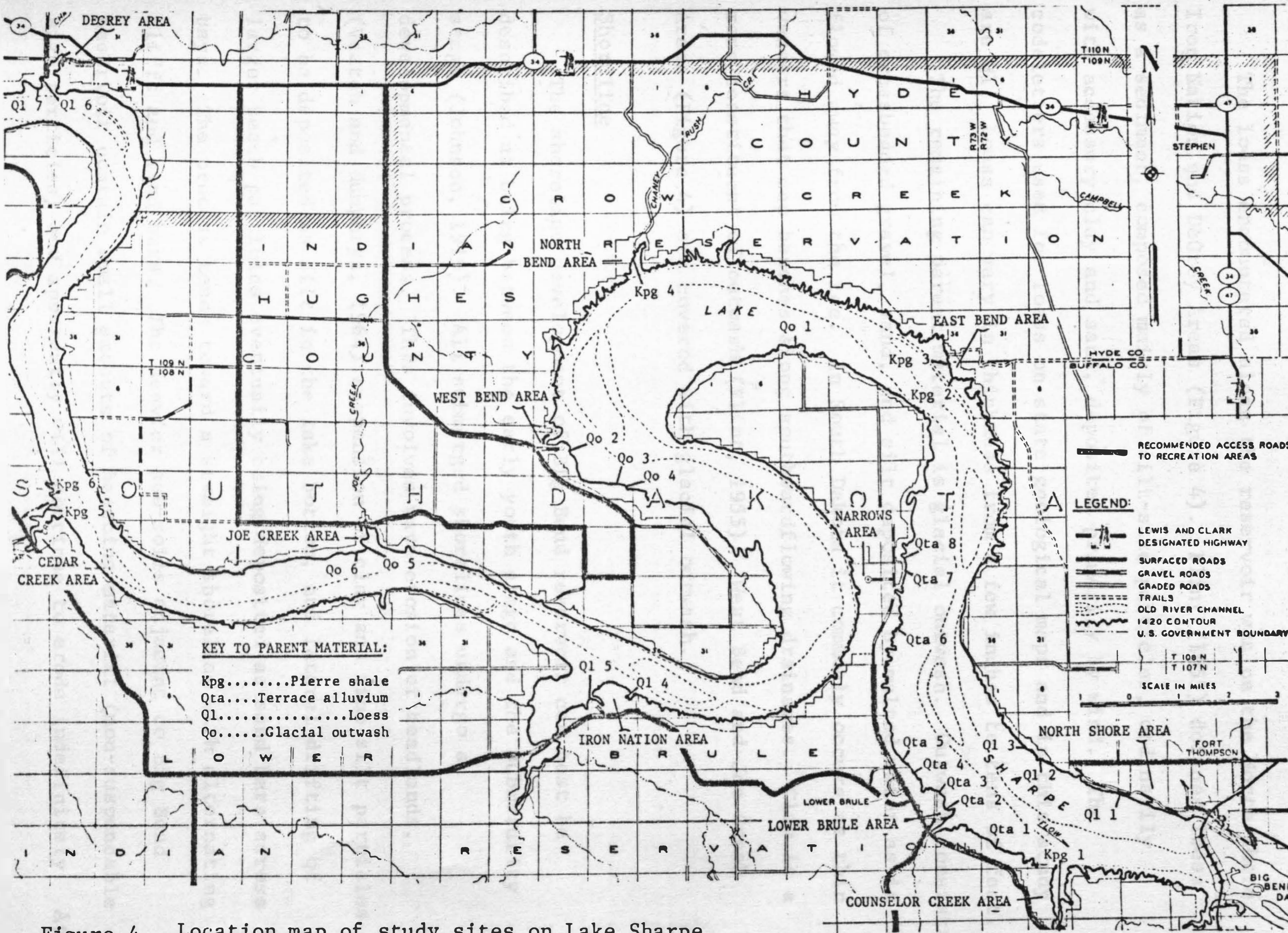


Figure 4. Location map of study sites on Lake Sharpe.

The loess encountered along the reservoir was on the North Shore, Iron Nation and DeGrey Areas (Figure 4). Flint (1955) defines loess as a sediment, composed mainly of silt-size particles, ordinarily with accessory clay and sand, deposited primarily by wind. The codeletters used for loess on state geological maps and in this study are Ql. Loess can vary in thickness from a few inches to tens of feet.

The remaining parent material is glacial outwash. Outwash consists of crossbedded gravel, sand, and silt deposited by melted water as it flowed away from the ice. In South Dakota it commonly occurs as thin veneers that cap benches along southwardflowing drainages. Clay is a rare constituent of outwash (Flint, 1955). West Bend and Joe Creek Areas (Figure 4) are covered with glacial outwash.

Shoreline

The shoreline development of Big Bend reservoir can best be described as being between the early youth stage and the submaturity stage (Johnson, 1919). All submerged shorelines undergo a developmental process. This involves wave erosion of headlands, (Veatch and Humphrys, 1964) suspension of clay and fine silt particles to be deposited as silt in the lake bottom, and lateral drifting of larger beach particles eventually being deposited as sand bars across bays. The process tends toward a straight shoreline with alternating cliffs and sand bars. The heavier sub-soils adjacent to Big Bend Reservoir contain small amounts of beaching material (non-suspendable size particles) and apparently will continue to erode indefinitely. At present the shoreline of Big Bend Reservoir is about 50% tall cliffs and 50% low profile. This study is concerned only with the low profile shoreline.

METHODS

Site selection

The study sites were selected to include natural tree seedlings growing along the margins of the reservoir. Two sites, Kpg 2 and Kpg 4, (Figure 4) did not include live seedlings, but did contain evidence of dead tree seedlings in the water near the shore. A survey was conducted in the summer of 1970 to determine if there were sufficient numbers of natural tree seedlings along the reservoir to warrant a study. Preliminary transects were made on two sites in 1970, and they were again mapped in 1971. The remaining sites were selected in the summer of 1971, by driving or walking along accessible shorelines and picking the most conspicuous tree seedlings. A minimum of six sites were selected on each of the four parent materials.

Transect

The type of transect or sampling strip (Oosting, 1956) used was a combination of the associational and belt transect described by Gates (1949). A starting point was located on typical grassland vegetation above the selected tree seedling, except in cases where barriers or extreme distances were involved. This vegetation in most cases was either wheatgrass (Agropyron) or brome (Bromus). The starting point was marked with a three foot wire stake, which served to anchor the measuring tape and mark the sites for follow-up studies. The 200-foot metal measuring tape was then stretched from the stake toward the reservoir passing over or near the selected tree seedling or seedlings. The tape marked the center line of a three-foot-wide belt transect that passed through the terrestrial succession zone ending at the reservoir. The terrestrial succession zone as used in this study is defined as the land area adjacent to the reservoir that is clearly different from typical grassland because of non-typical grassland vegetation. All transects were oriented perpendicular to the shoreline.

The next step was mapping all dominant vegetation inside the three-foot-wide belt. Mapping was done on graph paper with each square representing a square foot of the transect. A yardstick with a mark at 18 inches was used to delineate the boundaries on each side of the center tape. Identification of specimens was verified through the South Dakota State University herbarium. Plant species were identified on the map with code letters. The boundaries between plant associations were drawn on the map. An abrupt boundary was represented by a straight line, a gradual change was represented by a jagged line. When dominance appeared to be shared by 2 or more species, they were all identified and mapped. Densities were determined by counting the stems of a species in a square foot subsample within the transect. Densities of extensive species, occupying more than ten feet of the transect, were subsampled two or more times.

Elevation profile

An elevation profile of the transect was drawn immediately under each transect map. Reference stakes were set up parallel to and 100 feet from the transect. Ribbons were tied to these stakes at eye-level or about five feet two inches above the water level of the reservoir. Elevations of points on the transect were then determined by standing on the transect and shooting on the reference stake ribbons with an abney hand level. The elevations could then be read directly from the percent scale on the abney.

Presentation

Ease of understanding was the main criterion for presenting the transect information. The transect map and the elevation profile were combined to present a cross-section of the study site. A scale was selected on which one horizontal foot was equal to one typing space on an IBM Selectric typewriter. A capital X was typed for every foot in which a plant occurred on the transect. The elevation line was drawn to scale on the profiles. Non-tree vegetation heights were not measured in the study, therefore their profiles are only approximate. The tree seedlings were measured to the nearest foot and are so shown on the profiles. Profiles too large for a page were reduced on a 7000 Xerox copier.

Frequencies of species are given in percent of transects (Tables 1-4) in which they were found. Although the transects are ecologically equal, they do vary in physical length and Oosting (1956) warns of critically comparing frequencies from unequal sized plots.

RESULTS AND DISCUSSION

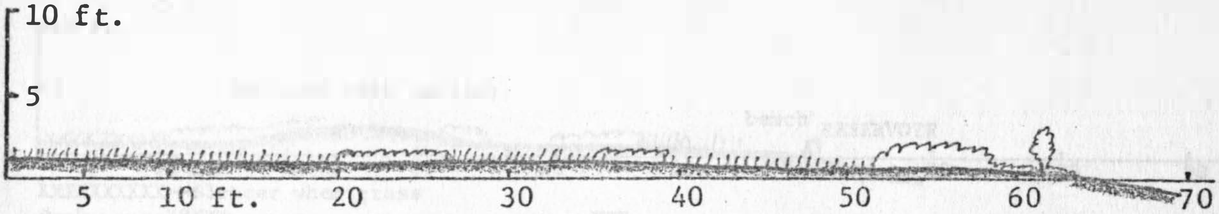
Pierre shale

Results from the six transects studied on shorelines having Pierre shale parent material showed 18 plant species identified as dominant (Table 1). Green ash seedlings were the objective on two transects (Figures 5 and 9). Two transects (Figures 6 and 8) had evidence of dead tree seedlings immediately off shore but were unidentifiable as to species. The remaining two transects selected included willow seedlings (Figures 7 and 10). Prickly pear was the only species occurring entirely outside the terrestrial succession zone or that area between the reservoir and the farthest extent of non-typical grassland vegetation (Figures 8 and 10). Barnyardgrass, dock, and slender wheatgrass had the highest frequencies (Table 1) each occurring in five of the transects. Slender wheatgrass was probably present when the new shoreline was created so should not be considered an active invader of the Pierre shale succession zone. Cocklebur was the only other plant to occur on more than 50 percent of the transects.

The width of the succession zone on Pierre shale transects ranged from 17 to 75 feet, with an average width of 42 feet (Figures 5-10). The maximum elevation of the succession zone was between 1 and 2 feet. The average maximum elevation was 1.3 feet. The presence of driftwood on the entire width of some succession zones (Figure 11), indicates that successful invasion of the grassland by non-grassland vegetation has occurred primarily on areas disturbed by high water. The

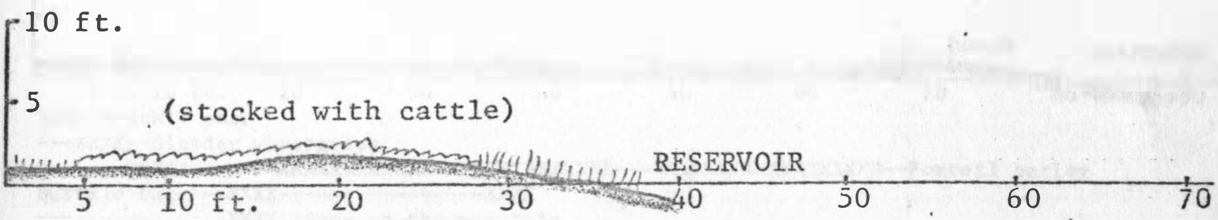
Table 1. Dominant Vegetation found within the Pierre Shale (Gregory member Kpg) Transects.

Common name	Frequency % of Transects	Density Stems/sq.ft.	Botanical name
Barnyardgrass	83	1-20	Echinochloa crusgalli
Beggar-ticks	17	2	Bidens frondosa
Blue grama	17	10	Bouteloua gracilis
Buffalo bur	17	1	Solanum rostratum
Cocklebur	67	1-2	Xanthium italicum
Common sunflower	17	4	Helianthus annuus
Dock	83	1-3	Rumex sp.
Foxtail barley	17	50	Hordeum jubatum
Giant ragweed	17	1-2	Ambrosia trifida
Green ash	33	1	Fraxinus pennsylvanica
Lady's thumb	33	1-5	Polygonum persicaria
Motherwort	17	6	Leonurus cardiaca
Prickly pear	33	1	Opuntia spp.
Slender wheatgrass	83	10-40	Agropyron trachycaulum
Snow-on-the-mountain	17	1	Euphorbia marginata
Sweetclover	17	10	Melilotus spp.
Western snowberry	17	1	Symphoricarpos occidentalis
Willow	33	1	Salix spp.



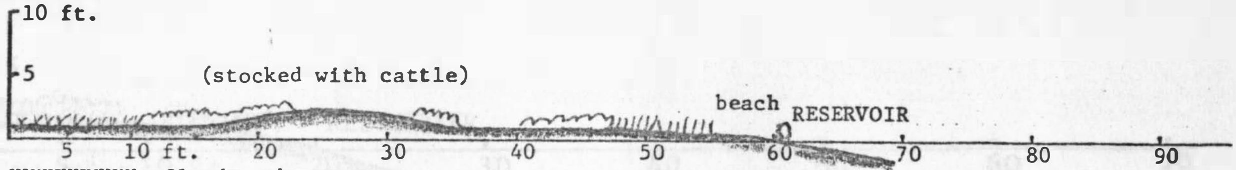
XXXXXXXXXXXXXXXXXXXX------XXXXXXXXX---XXXXXXXXXXXXX--Slender wheatgrass
Giant ragweed-------XXX-----------XXXX
Beggar-ticks-----------XXX
Common sunflower------------------------------------XXXXXXX
Motherwort--XXXX
Green ash---X

Figure 5. Profile of transect Kpg 1, Counselor Creek Area, center Sec.31, T107N, R72W, August, 1971.



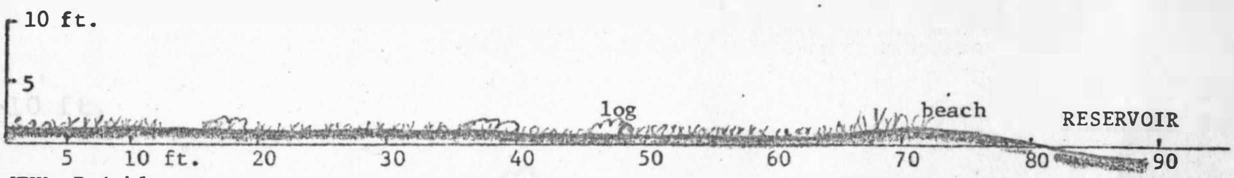
XXXX--Slender wheatgrass
----XXXXXXXX--Dock
----XXXXXXXXXXXXXXXX---XXXX--Cocklebur
Lady's thumb--------XXX
Barnyardgrass----------------XXXXXXXXXX

Figure 6. Profile of transect Kpg 2, East Bend Area, center Sec.2, T108N, R73W, August, 1971.



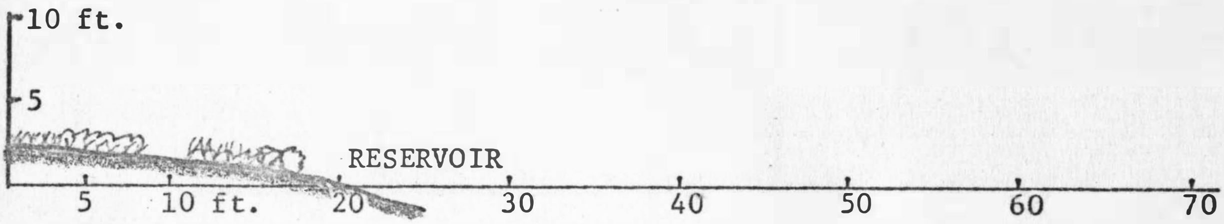
XXXXXXXXXXX--Slender wheatgrass
Dock------XXXXX------------------------------XXX
Cocklebur------XXXXXXX------------------XXX
Lady's thumb--------------------XXXX
Barnyardgrass----------------------------------XXXXXXXX
Willow---X

Figure 7. Profile of transect Kpg 3, East Bend Area, N1/2, Sec.2, T108N, R73W, August, 1971.



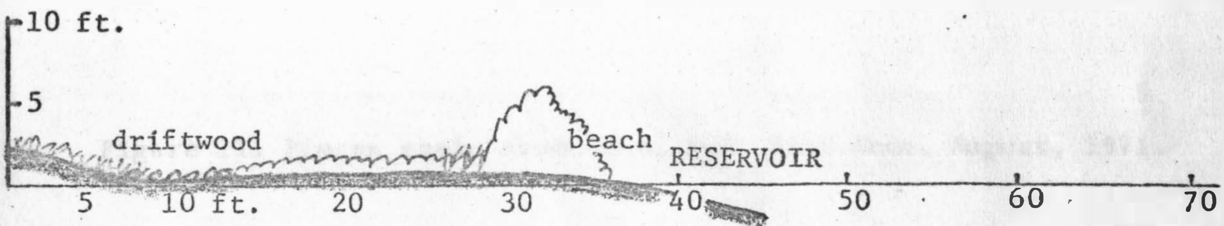
XXX--Prickly pear
---XXXX--Slender wheatgrass
-------XXXXX-------XXXXXXXXXXXXXXXXXXXXXXXXXX---XXXXXXXXXXXXXXXXXX--Foxtail barley
Buffalo bur----XXXX----------------XXXX
---------------XXXX--Snow-on-the-mountain
Dock------------------------------------XXX
Barnyardgrass---XXXXX

Figure 8. Profile of transect Kpg 4, North Bend Area, SE1/4, SE1/4, Sec.23, T109N, R74W, August, 1971.



XXXXXXXX--Blue grama
---XXXXX--Sweetclover
-----------XXXXX--Barnyardgrass
Cocklebur--XXXXX
Dock-------XXXXX
---------------XX--Western snowberry
Green ash-------X

Figure 9. Profile of transect Kpg 5, Cedar Creek Area, NE1/4, Sec.22, T108N, R76W, September, 1971.



XXXXXXXX--Slender wheatgrass
-XX--Prickly pear
Cocklebur----XXXXXXXXXXXX
Dock---------------------XX
Barnyardgrass------------XX
Willow---------------------XXXXXXXX

Figure 10. Profile of transect Kpg 6, Cedar Creek Area, SE1/4, Sec.15, T108N, R76W, September, 1971.

Figure 11. Pierre shale shoreline, East Bend Area, August, 1971.

sheltered Pierre shale shorelines (Sites Kpg 1, 4 and 5, Figure 4) did not have extensive driftwood; however, the elevation of the succession zone indicates that they have also been disturbed by high water.

Tree seedlings on the Pierre shale transects were growing at a maximum elevation from 0 to 1 foot above the reservoir. The average maximum growing site elevation was .25 feet or 3 inches. The maximum distance of the trees from the reservoir ranged from 0 to 10 feet, with an average maximum distance of 4.2 feet. Possible explanations for the close proximity of the tree seedlings to the reservoir on Pierre shale are that the transport of the tree seeds may have been largely by water; therefore, they could not be carried any higher or farther inland than the high water line. Considering the lightness of willow seed and the presence of green ash in local ravines far from water make this explanation unlikely. Another possibility is that the only place tree seeds could successfully germinate and grow was near water. The relative impermeability of Pierre shale and the difficulty plants have extracting moisture from clay soils make this a more plausible explanation. Observations on the low success of tree plantings on several Pierre shale areas add further support to the inhospitable nature of such sites to tree growth.

Tree seedlings that grow below the high water level are subjected to flooding, storms, shore erosion, and ice damage during spring breakup. Ice driven by spring storms probably explains the ridges of soil present on several of the transects (Figures 6-8). These hazards probably account for poor height growth and scarcity of tree seedlings on Pierre shale shore lines. The average maximum tree height on the Pierre shale transects was 2.5 feet.

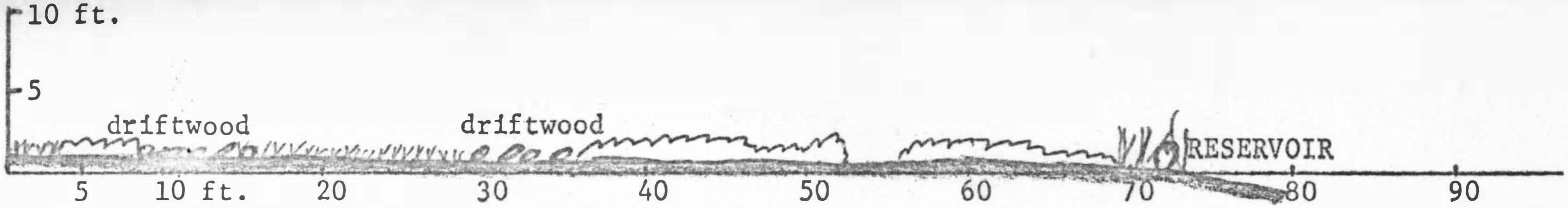
Terrace alluvium

Results of studies made in 1971, on eight terrace alluvium transects showed 24 species classified as dominant (Table 2). Five of the eight transects contained willow seedlings (Figures 12, 14, 15, 16 and 19). Five also contained eastern cottonwood seedlings (Figures 13, 14, 15, 18 and 19). Only one transect was run to study the conditions associated with green ash (Figure 17). All of the species identified occurred at least partially within the defined terrestrial succession zone (Figures 12-19). Highest frequency was shared by three species; barnyardgrass, cocklebur, and dock each occurred in six of the eight transects. Nine plant species occurred in four or more transects (Table 2). For purposes of selecting a starting point and measuring the terrestrial succession zone, japanese brome, slender wheatgrass and smooth brome were considered typical grassland vegetation.

The width of the terrestrial succession zone on the terrace alluvium transects ranged from 45 to 110 feet (Figures 13 and 19). The average width was 79 feet. One transect had an extensive area of cat-tails growing in the reservoir (Figure 13). This was considered a part of an aquatic succession process and was not included as part of the terrestrial succession zone. The maximum elevations of the

Table 2. Dominant Vegetation found within the Terrace Alluvium (Qta) Transects in 1971.

Common name	Frequency % of Transects	Density stems/sq.ft.	Botanical name
Barnyardgrass	75	4-10	Echinochloa crusgalli
Cat-tail	62	1-5	Typha angustifolia
Cocklebur	75	1-4	Xanthium italicum
Common sunflower	50	1-2	Helianthus annuus
Cyperus	12	3	Cyperus spp.
Dock	75	1-10	Rumex sp.
Eastern cottonwood	62	1	Populus deltoides
Foxtail barley	25	10	Hordeum jubatum
Giant ragweed	62	1-4	Ambrosia trifida
Green ash	12	1	Fraxinus pennsylvanica
Japanese brome	38	15-20	Bromus japonicus
Kochia	25	10-20	Kochia scoparia
Lady's thumb	25	1-10	Polygonum persicaria
Many-flowered aster	12	3	Aster ericoides
Motherwort	25	1-5	Leonurus cardiaca
Prairie bulrush	12	2-3	Scirpus maritimus
Rice cutgrass	12	20	Leersia oryzoides
Slender wheatgrass	62	15-20	Agropyron trachycaulum
Smooth brome	12	10	Bromus inermis
Stick-tight	25	1-10	Bidens cernua
Sweetclover	25	1-10	Melilotus spp.
Western snowberry	12	5	Symphoricarpos occidentalis
Willow	62	1	Salix spp.
Witchgrass	25	3-10	Panicum capillare



XXXX--Japanese brome

---XXXXX--Common sunflower---------XXXXXXXXXXX----XX

--------------XXXXXXXXXXXXXX--Slender wheatgrass

Cocklebur-------------------------------------XXXX-----XXXXXXXXX

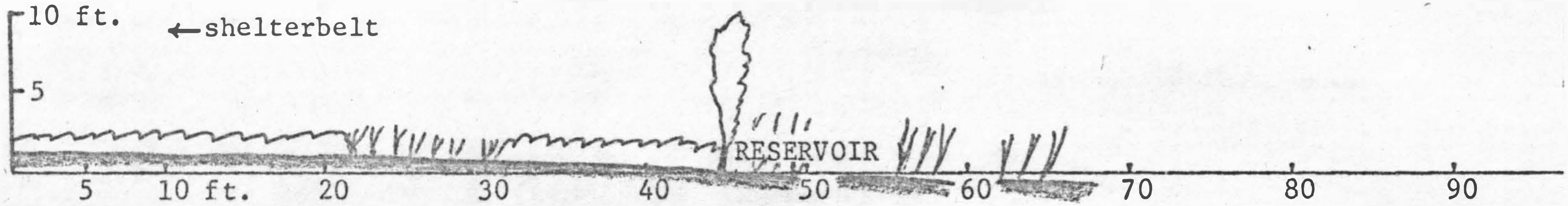
Dock---XX

Motherwort--XXXX

Cat-tail---XXXXX

Willow---X

Figure 12. Profile of transect Qta 1, two mi. SE of Lower Brule Area, S1/2, Sec.24, T107N, R73W, August, 1971.



XXXXXX----XXXXXXXXXXX--Common sunflower

XXXXXX----XXXXXXXXXXX--Dock

------XXXX--Sweetclover

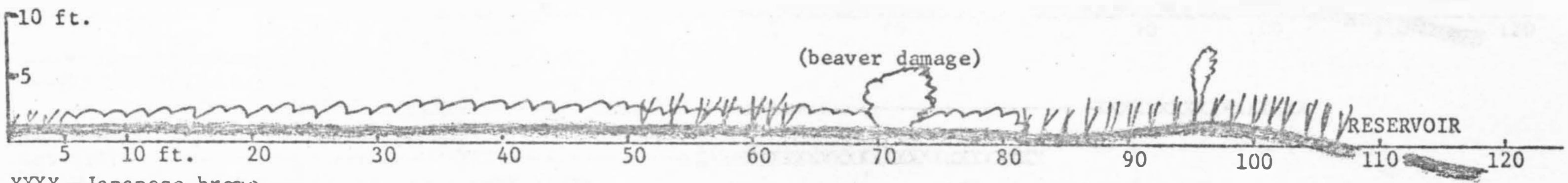
Barnyardgrass--------XXXXXXXXX

Giant ragweed-----------------XXXXXXXXXXXXXXX

Eastern cottonwood-------------------------X

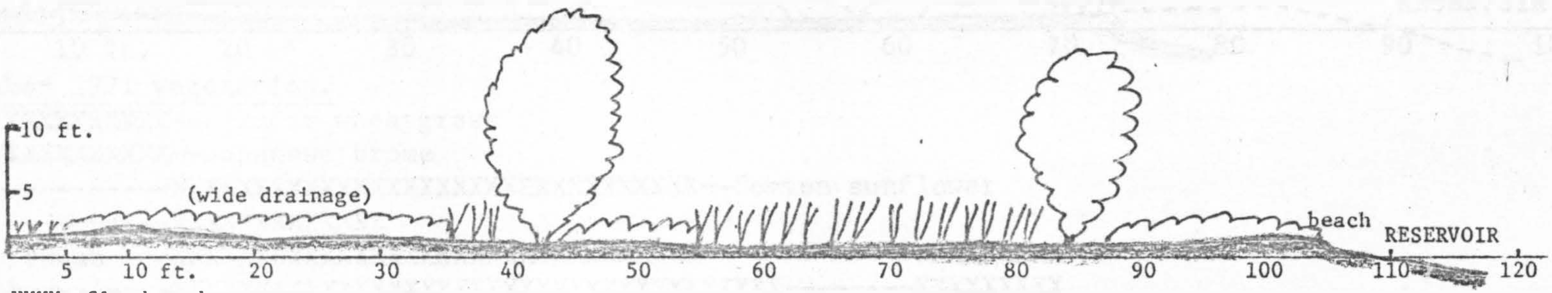
Cat-tail-------------------------------------XXXXXXXXXXXXXXXXXX approx. 100 ft. into reservoir.

Figure 13. Profile of transect Qta 2, Lower Brule Area, SW1/4, SW1/4, Sec.14, T107N, R73W, August, 1971.



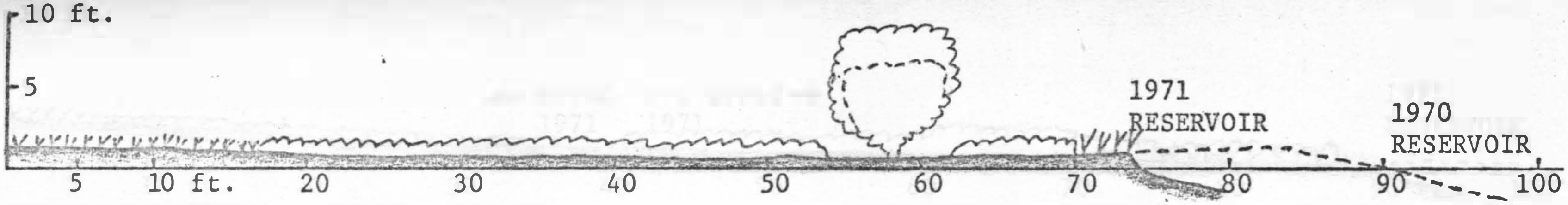

```
XXXX--Japanese brome
----XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX--Giant ragweed
----XXXXXXXXXXXXXXXXXXXXXXXXXXXXXX--Dock--------------------XXXXXXX-----XXXXXXXXX
Stick-tight-----------------------XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX-----XXXXXXXXX
Barnyardgrass-------------------------------------XXXXXXXXXXXX
Eastern cottonwood-------------------------------------------XXXXX
Cat-tail------------------------------------------------------------------XXXXXXXXXXXXXXXXXXXXXXXXXX
Willow----------------------------------------------------------------------------------X
```

Figure 14. Profile of transect Qta 3, Lower Brule Area, NW1/4, SW1/4, Sec.14, T107N, R73W, August, 1971.



XXXX--Slender wheatgrass
----XXXXXXXXXXX--Stick-tight
------XXXXX----XXXXXXXXXXXXXXXXXXXX-----------XXXXXXXX--Cocklebur---------------------XXXXXXXXXXXXXXXXX
Giant ragweed----------XXXXXXXXXXXX-----------XXXXXXXX
Cat-tail---------------------------XXX---------------
Willow---------------------------------XXXXXXXX
Rice cutgrass-------------------------------------XXXXX
Barnyardgrass--XXXXXXXXXXXX
Eastern cottonwood---XXXX

Figure 15. Profile of transect Qta 4, Lower Brule Area,
N1/2, Sec.15, T107N, R73W, September, 1971.



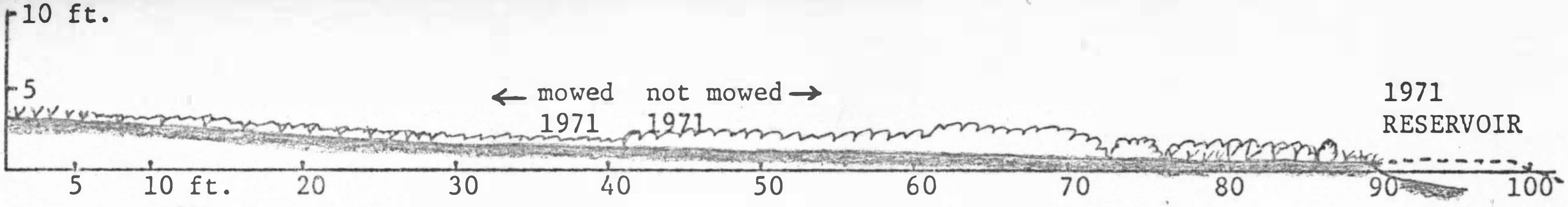
September 1971 vegetation.

XXXXXXXXXXXXXXXX--Slender wheatgrass
XXXXXXXXXXXXXXXX--Japanese brome
----------------XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX--Common sunflower
Dock------------XXXXXXXXXXXXX
Lady's thumb----XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX-------------XXXXXXXXX
Cocklebur-------XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX--------XXXXXXXXX
Giant ragweed----------------XXXXXXXXXXXXXXXXXXXXXXXX
Willow---XXXXXXXX
Cat-tail---XXX

September 1970 vegetation.

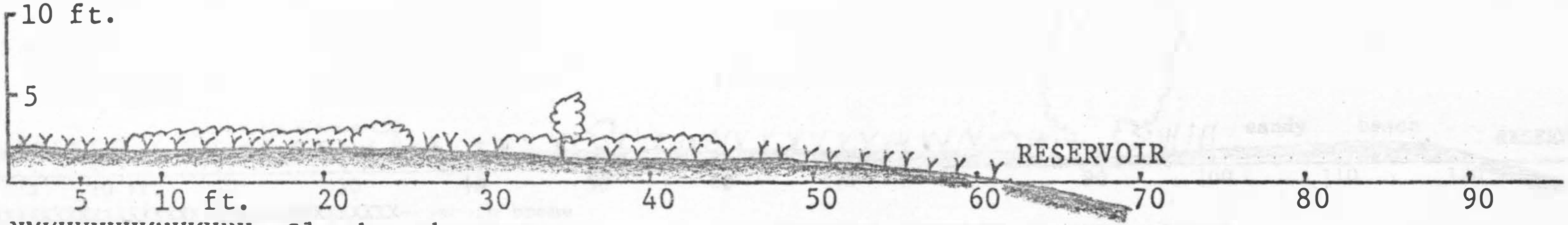
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX-----XXXXXXXXXXXXXXX--Slender wheatgrass
XXXXXXXXXXX--Japanese brome
XXXXXXXXXXXXXXXXXXXXXXX--Blue grama
Giant ragweed----------------------------------XXXXXXXX------XXXXXXXXXXXXXXX-----XX
Willow---XXXXXX
Cat-tail---XXXXXX

Figure 16. Profile of transect Qta 5, Lower Brule Area, S1/2, S1/2, Sec.10, T107N, R73W, September, 1970 and September, 1971.



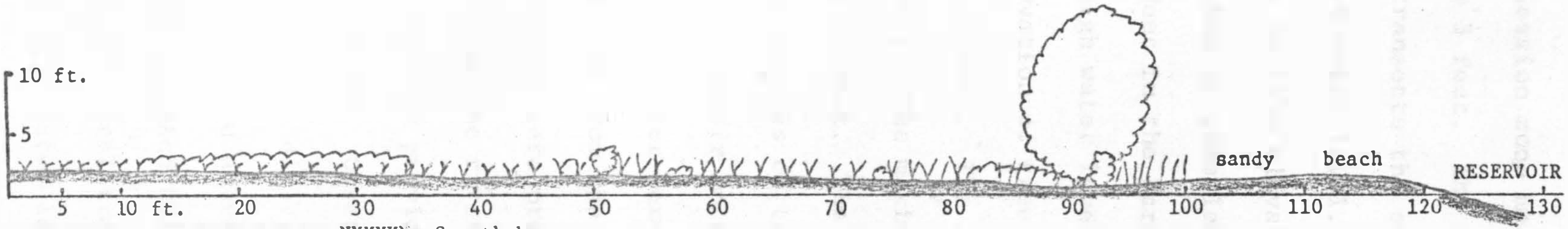

```
September 1971 vegetation.
XXXXXXXXXXXXXXXXXXXXXXXXXXXX--Slender wheatgrass--------------------------------------XXXX
-----XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX--Kochia
Cocklebur-----------------------------------------------------XXXXXXXXXXXXX-------XXXXXXX
Common sunflower----------------------------------------------XXXXXXXXXXXXX
Dock----------------------------------------------------------XXXXXXXXXXXXX-------XXXXXXX
Western snowberry----------------------------------------------------------XXX
Witchgrass------------------------------------------------------------------XXXXX
Lady's thumb----------------------------------------------------------------XXXXX
Barnyardgrass-------------------------------------------------------------------XXXXXXX
Green ash---------------------------------------------------------------------------X
Motherwort------------------------------------------------------------------------------XXXX

September 1970 vegetation.
XXXXXXXXXXXXXXXXXXXXXXXXX--Slender wheatgrass--------------------------------XXXXXXXXXXXXX
----XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX--Kochia
Many-flowered aster-------------------------------------------------XXXXX
Western snowberry-----------------------------------------------------XX
Common sunflower--------------------------------------------------------XX
Stick-tight---------------------------------------------------------------XXXXXXX
Motherwort-------------------------------------------------------------------------XXXX
Green ash----------------------------------------------------------------------------X-XXXX
Rice cutgrass-------------------------------------------------------------------------------XXXX
```

Figure 17. Profile of transect Qta 6, Narrows Area, NW1/4, Sec.34, T108N, R73W, September, 1970 and September, 1971.



XXXXXXXXXXXXXXX--Slender wheatgrass
------XXXXXXXXXXXXXXXXX--Kochia
--------------XXXXXXXXX--Foxtail barley
Many-flowered aster--XXXX
Barnyardgrass---------XXXXXXXX------XXXXXXXXXXXXXXXXXXXXXXXXXX
Cocklebur---------------------XXXXXXXXXXXXXX
Eastern cottonwood----------------X

Figure 18. Profile of transect Qta 7, Narrows Area, N1/2, Sec.27, T108N, R73W, September, 1971.




```
                                          XXXXXX--Smooth brome
----------XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX---XXXXXXXXXXXXXXX-XXXXXXXXXXXX--Barnyardgrass
----------XXXXXXXXXXXXXXXXXXXXXXXXX--Sweetclover
----------XXXXXXXXXXXXXXXXXXXXXXXXX--Foxtail barley
Eastern cottonwood--------------------------------XX----------------------------------------X
Cocklebur-----------------------------------------------XX
Dock------------------------------------------------------------------X-----------XXX
Praire bulrush------------------------------------------------------------XXXXXXXXXXXX--------XXXXX
Giant ragweed-------------------------------------------------------------------XXXXXX
Cyperus-----------------------------------------------------------------------XXXXXX
Witchgrass--------------------------------------------------------------------------XXX
Willow------------------------------------------------------------------------------XXXXXXXX
```

Figure 19. Profile of transect Qta 8, Narrows Area, S1/2, Sec.22, T108N, R73W, September, 1971.

terrestrial succession zone measured on the terrace alluvium transects ranged from 1 to 3 feet. The average maximum elevation was 1.5 feet. On most of the transects the succession zone did not extend far beyond the probable high water level. Due to gentle slope of terrace alluvium just a foot rise in lake elevation inundates a large area (Figure 20). Successful invasion of grassland by kochia has occurred up to an elevation of 3 feet in the Narrows Area (Figure 17). This is about a foot above the high water level.

Maximum elevation of tree seedling sites on terrace alluvium ranged from 0 to 1 foot. The average maximum elevation was .38 feet or about 4.5 inches. The maximum distance of trees from the reservoir ranged from 1 to 70 feet. The average maximum distance was 27.9 feet.

The apparent success of tree seedling germination and growth farther from the reservoir on terrace alluvium than on Pierre shale is probably due to greater permeability of terrace alluvium. When the shale was washed down from the hills and redeposited as alluvium the smaller clay particles were probably held in suspension and carried farther down slope to the river. A faster rate of ground water movement from the reservoir would provide favorable tree growing conditions farther away from shore. Observations of planted shelterbelts on terrace alluvium show a fairly strong correlation between survival and elevation. Trees planted above the 5 foot elevation line showed less survival than those planted below the 5 foot elevation line.

The ability of several tree seedlings to survive the hazards of growing below the high water level is probably due to several reasons.

Figure 20. Terrace alluvium shoreline, Lower Brule Area, August, 1971.

Some have probably been protected from storm and erosion damage by dense stands of cat-tail (Figures 13 and 14). The presence of offshore vegetation and the distance of terrace alluvium shoreline from the original river channel (Figure 4) indicate shallow water. Shallow water and the infrequency of strong northeast winds could lessen the strength of waves coming ashore. Shore erosion is present however; studies in 1970 and 1971 on two transects (Figures 16 and 17) showed extensive erosion over a one-year period. Several of the unprotected trees may be in danger from erosion in the next few years (Figures 12, 15, 16, 17 and 18). One transect is protected by a sandy beach (Figure 19). Studies showed that the sand was probably transported by lateral beach drifting from sources farther north. The average height of the tallest tree in each transect was about 7.5 feet.

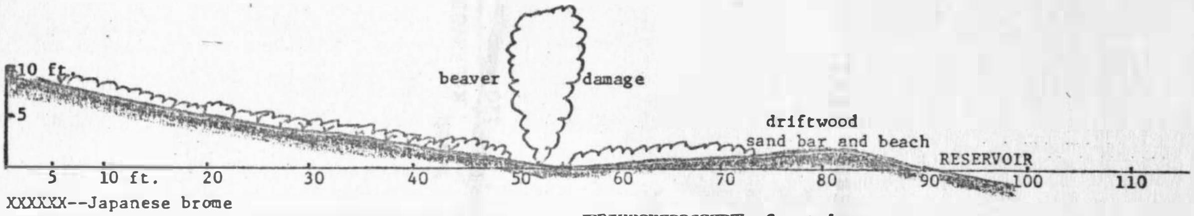
Loess

Results from seven transects on loess parent material showed 25 plants as dominant (Table 3). Tree species identified were eastern cottonwood on three transects (Figures 21-23) and green ash on four transects (Figures 24-27). Japanese brome and western wheatgrass did not occur in any succession zone (Figures 21 and 26). Barnyardgrass, dock and slender wheatgrass each occurred in five transects. Seven of the 25 species occurred in four or more of the transects (Table 3).

The width of the succession zone on loess ranged from 42 to 115 feet (Figures 23 and 24). Average width was 73 feet. Most succession zones extended far beyond high water level (Figures 21-27). The

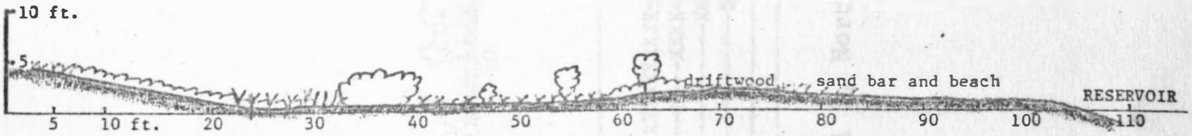
Table 3. Dominant Vegetation found within the Loess (Q1) Transects.

Common name	Frequency % of Transects	Density stems/sq.ft.	Botanical name
Barnyardgrass	71	1-15	Echinochloa crusgalli
Cat-tail	43	1	Typha angustifolia
Cocklebur	57	1-3	Xanthium italicum
Common ragweed	57	2-15	Ambrosia elatior
Common sunflower	29	1	Helianthus annuus
Cyperus	43	1-6	Cyperus spp.
Dock	71	1-5	Rumex sp.
Eastern cottonwood	43	1	Populus deltoides
False indigo	14	1	Amorpha fruticosa
Foxtail barley	29	5	Hordeum jubatum
Giant ragweed	14	2	Ambrosia trifida
Green ash	57	1	Fraxinus pennsylvanica
Japanese brome	14	10	Bromus japonicus
Kochia	29	1-10	Kochia scoparia
Lady's thumb	14	3	Polygonum persicaria
Major plantain	14	1	Plantago major
Many-flowered aster	29	2-10	Aster ericoides
Prairie bulrush	14	10	Scirpus maritimus
Prickly lettuce	14	4	Lactuca virosa
Slender wheatgrass	71	10-30	Agropyron trachycaulum
Smooth brome	14	15	Bromus inermis
Sweetclover	57	3-15	Melilotus spp.
Western snowberry	14	4	Symphoricarpos occidentalis
Western wheatgrass	14	20	Agropyron smithii
Witchgrass	14	5-8	Panicum capillare



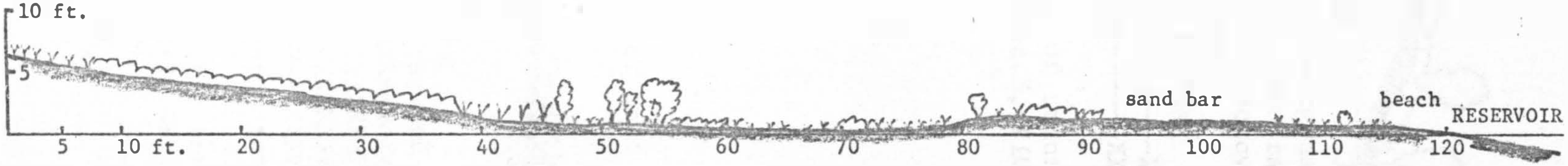
XXXXXX--Japanese brome
------XXXXXXXXXXXXXXXX--XXXXXXXXXXXXXXXXXXXXXXX------------XXXXXXXXXXXXXXXXX--Sweetclover
------------------XXXX--Many-flowered aster
Slender wheatgrass-----XXXXXXXXXXXXXXXXXXXXXX
Common ragweed----------------------------XXXXXX
Eastern cottonwood------------------------------XXXXXXXX
Cocklebur--XXXXXXXX

Figure 21. Profile of transect Ql 1, North Shore Area, SW1/4, Sec.16, T107N, R72W, September, 1971.



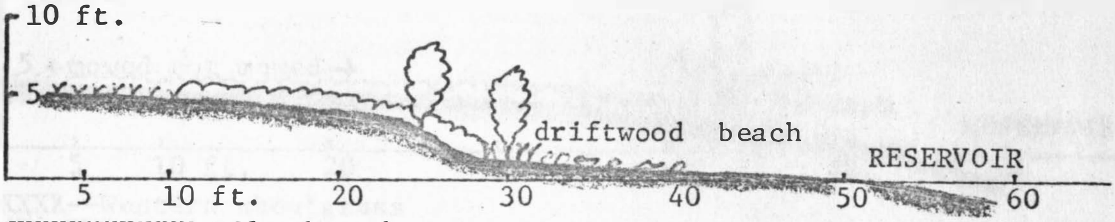
XXXXXXX--Slender wheatgrass
-------XXXXXXXXXXXXXXX--Sweetclover-----------------------XXXXXXXXXXXXX
Cat-tail--------------XXXXXXX
Cocklebur-------------XXXXXXX---XXXXXXXXXXXX
Barnyardgrass----------------XXX--------XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
Praire bulrush---------------XXX
Eastern cottonwood-------------XXXXXXXX------X-------X------X
Cyperus-------------------------------------XXXXXXXXXXXXXXXXXXXX
Foxtail barley--------------------------------XXXXXXXXXXXX
Dock--XXXXXXXXXXXXXXXXXXXXXXXX

Figure 22. Profile of transect Ql 2, North Shore Area, S1/2, Sec.7, T107N, R72W, September, 1971.



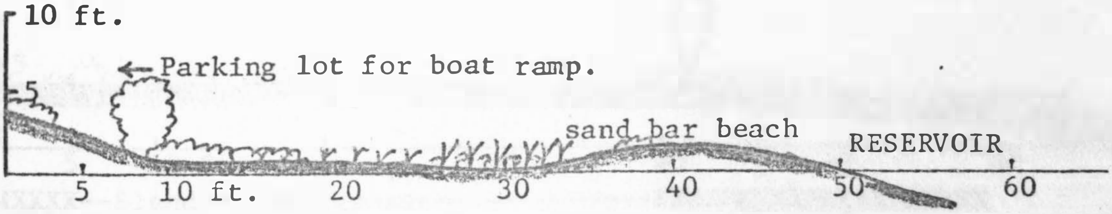
XXXXXXXXX-----XXXXXXXXXX--Slender wheatgrass
Kochia-XXXXXXXXXXXXXXXXX
Common ragweed----------XXXXXX
Cocklebur---------------------XXXXXX---XX
Cat-tail----------------------------XXXXXXXX
Cyperus-------------------------------------XXXXXXXXXXXXXXXXXXXXXXXX-------------------------------------XXXXXXXX
Eastern cottonwood---------------------------X---XXXXXX-----------------------X-----------------------------X
Major plantain--XXXXXX
Foxtail barley--XXXXXXXXXXXXX---XXXXXXXXXXXXX
Dock---XXXX------------XX
Common sunflower---XXX

Figure 23. Profile of transect Q1 3, North Shore Area, SW1/4, Sec.7, T107N, R72W, August, 1971.



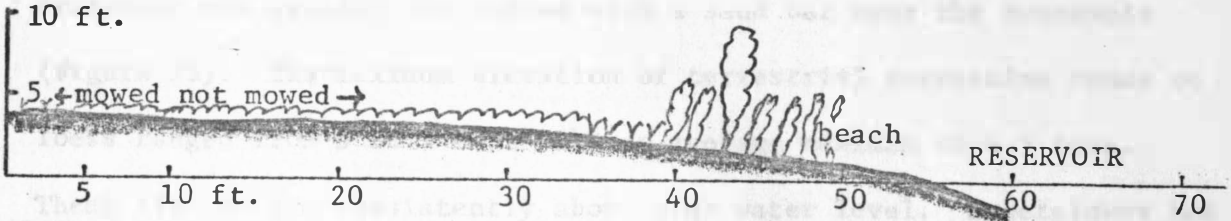
XXXXXXXXXXXX--Slender wheatgrass
----------XXXXXXXXX--Common ragweed
----------XXXXXXXXX--Sweetclover
Common sunflower---XXXX
Many-flowered aster-XXXXXXXX
Green ash---------------X----X
Barnyardgrass---------------XXX

Figure 24. Profile of transect Ql 4, Iron Nation Area, E1/2, Sec.3, T107N, R74W, September, 1971.



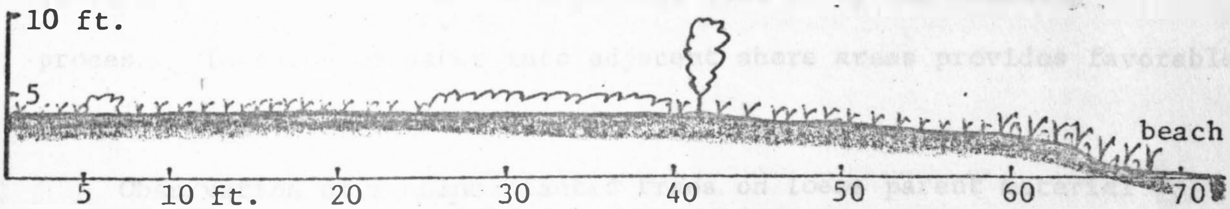
XXX--Sweetclover
------XXX--Green ash
---------XXXX--Common ragweed
------------XXXXXXXXXXXX--Barnyardgrass
Dock--------XXXXXX-----XXXXXXXXXXXX
Cyperus-----------------XXXXXXXXXXXX
Cat-tail-----------------XXXXXXX
Cocklebur--------------------------XX

Figure 25. Profile of transect Ql 5, Iron Nation Area, W1/2, W1/2, Sec.3, T107N, R74W, September, 1971.



XXXX--Western wheatgrass
----XXXXXXXXXXXXXX--Kochia
Dock-------XXXXXXXX
Witchgrass--------XXXXXX---XXXXXXX
Giant ragweed-------XXXXXX
Lady's thumb------------XXX
Barnyardgrass-------------------XXXXXX
False indigo-----------------------XXXXXXXX
Green ash-------------------------------X

Figure 26. Profile of transect Q1 6, DeGrey Area,
E1/2, Sec.2, T109N, R76W, September, 1971.



XXXXX--Slender wheatgrass--------------XXXXXXXXXXXXXXXXXXXXX
-----XX--Prickly lettuce
-------XXXXXXXXXXXXXXXXXXX--Smooth brome
Western snowberry--------XXXXXXXXXXXXXXX
Green ash-------------------------------X
Barnyardgrass---XXXXXXXX
Dock---XXXXXXXX

Figure 27. Profile of transect Q1 7, DeGrey Area,
E1/2, Sec.2, T109N, R76W, September, 1971.

driftwood was usually associated with a sand bar near the reservoir (Figure 28). The maximum elevation of terrestrial succession zones on loess ranged from 3 to 9 feet with an average maximum of 4.7 feet. These figures are consistently above high water level. Sweetclover has invaded grassland to an elevation of 9 feet on one transect (Figure 21); a tap rooted species, it is probably extracting ground water from the reservoir.

Tree seedlings occurred at a maximum elevation range of 0 to 4 feet on the loess transects. The average maximum elevation was 1.57 feet. The maximum distance of trees from the reservoir ranged from 15-76 feet. The average maximum distance was 43.6 feet. The greater average distance of trees from the reservoir on loess than on preceding parent materials is more likely due to the greater permeability of loess and of the sand that is separated from it by the beaching process. Invasion of water into adjacent shore areas provides favorable tree seedling sites farther inland.

Observation of machine planted trees on loess parent material indicates fair survival up to about 1435 feet above sea level or 15 feet above the reservoir. The North Shore Area where over 30 shelter-belts were planted in 1964 and 1965 sustained heavy losses since cultivation was discontinued in 1970. The North Shore Area is a loess bench with an elevation between 1450 and 1460 feet above sea level or 30 to 40 feet above the reservoir.

Figure 28. Loess shoreline, North Bend Area, August, 1971.
Note cottonwood seedlings in the background.

Loess transects (Figures 21-27) show that most of the trees, although located at low elevations, are protected from storm and ice damage by sand bars. Natural tree growth is usually found in bays which lie between eroded headlands connected by sand bars (Figure 28).

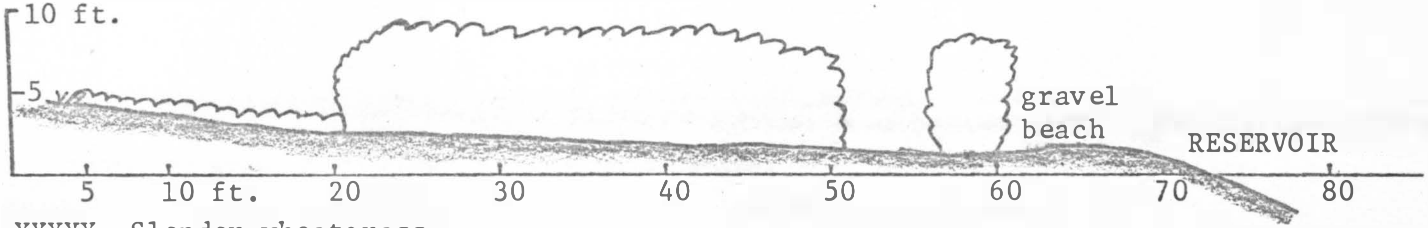
Glacial outwash

Data from six transects on glacial outwash parent material showed 26 dominant plant species (Table 4). Willow was present on four of the sites (Figures 29, 30, 31 and 33) and green ash was present on three (Figures 32-34). Western wheatgrass was the only species not included in a succession zone (Figure 33). Four species occurred in four transects to share the highest frequency; they were cocklebur, dock, sweetclover and willow. Four additional species occurred in three transects (Table 4).

The succession zone on glacial outwash ranged from about 70 feet to 245 feet wide (Figure 30). The average width of the succession zone was 108 feet. All succession zones on glacial outwash extended beyond high water level. The width of one succession zone was estimated (Figures 30 and 35) and the width of two more were arbitrarily determined because of the extreme distance from the reservoir to typical grassland vegetation (Figures 31 and 32). Only the length of the transect was used in the latter cases for calculating succession zone width and maximum elevation. The maximum elevation of the succession zone ranged from 1 foot on one of the transects that was arbitrarily stopped (Figure 31) to 10 feet (Figure 33). The average

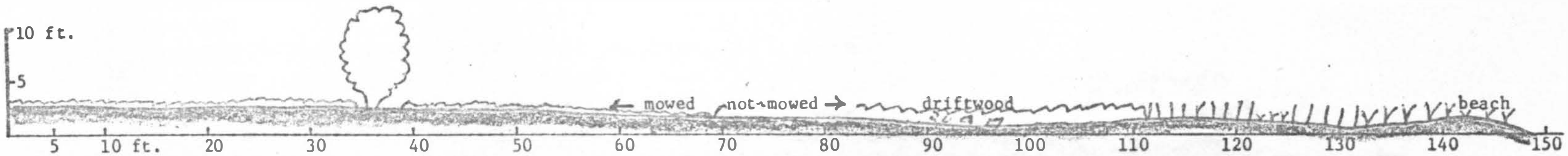
Table 4. Dominant Vegetation found within the Glacial Outwash (Qo) Transects.

Common name	Frequency % of Transects	Density Stems/sq.ft.	Botanical name
Barnyardgrass	50	1-5	Echinachloa crusgalli
Beggar-ticks	50	3-10	Bidens frondosa
Cat-tail	17	2	Typha angustifolia
Cocklebur	67	1-5	Xanthium italicum
Common sunflower	17	3	Helianthus annuus
Cyperus	17	8	Cyperus spp.
Dock	67	1-5	Rumex sp.
Giant ragweed	33	1-2	Ambrosia trifida
Green ash	50	1	Fraxinus pennsylvanica
Kochia	17	3	Kochia scoparia
Many-flowered aster	17	1	Aster ericoides
Missouri goldenrod	17	2	Solidago missouriensis
Motherwort	17	5	Leonurus cardiaca
Prickly lettuce	17	4	Lactuca virosa
Rice cutgrass	33	30	Leersia oryzoides
Showy milkweed	17	1	Asclepias speciosa
Slender wheatgrass	50	15-25	Agropyron trachycaulum
Smooth brome	17	13	Bromus inermis
Spike rush	17	40	Eleocharis spp.
Sweetclover	67	1-10	Melilotus spp.
Western snowberry	17	3	Symphoricarpos occidentalis
Western wheatgrass	17	30	Agropyron smithii
Wild bean	17	2	Strophostyles helvola
Wild rose	17	2	Rosa spp.
Willow	67	1	Salix spp.
Witchgrass	17	10	Panicum capillare



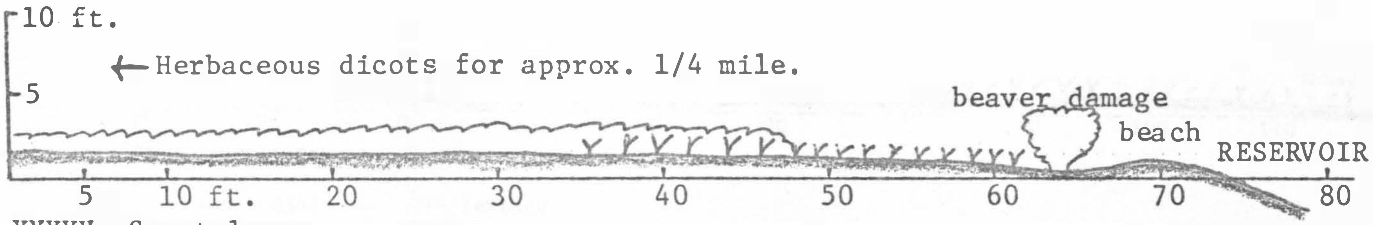
XXXXX--Slender wheatgrass
---XXXXXXXXXXXXXXXXX--Sweetclover
Willow-----------XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX-----XXXX
Dock------------------------XXXXX

Figure 29. Profile of transect Qo 1, four mi. N of Narrows Area, SW1/4, Sec.33, T109N, R73W, September, 1971.



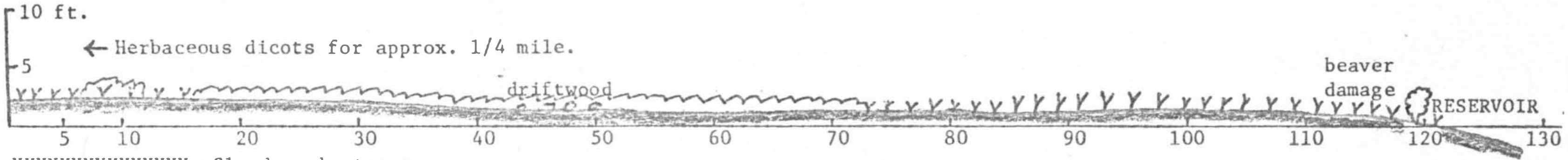
XXXXXXXX--Kochia continuous for approx. 100 ft. inland and 2 ft. higher in elevation.
--------XXX-------------------XXXX--Common sunflower
Dock-------XXXXXXXXXXXXXXXXXXX--------XXXXXXXXXXXXXXXXXXXXXXXXXXXXXX------------
Willow------------------------XXXXXXXXX
Cocklebur---XXXXXXXXXXXXXX---------------------XXXXXXX
Beggar-ticks--XXXXXXXXXXXXXXX
Giant ragweed---XXXXXXXXX
Spike rush---XXXXXXXXXX---XXXXXX
Cyperus---XXX
Cat-tail---XXXXXXXXXXXXXX

Figure 30. Profile of transect Qo 2, West Bend Area, center Sec.10, T108N, R74W, Sept. 1971.



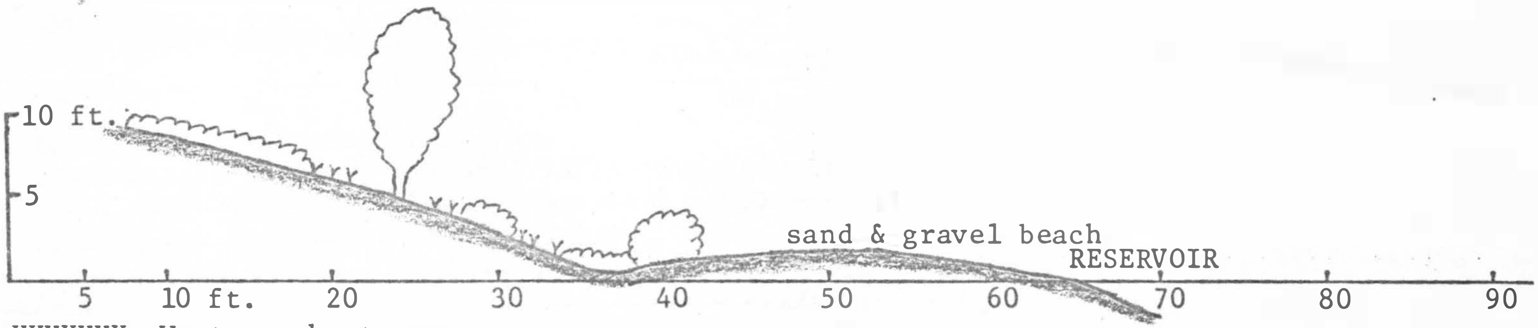
XXXXX--Sweetclover
Dock-XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
-----XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX--Beggar-ticks
Barnyardgrass--------------------XXXXXXXXXXXXXX
Rice cutgrass----------------------------------XXXXXXXXXXXXXX
Willow--XXXXX

Figure 31. Profile of transect Qo 3, West Bend Area, E1/2, Sec.14, T108N, R74W, September, 1971.




```
XXXXXXXXXXXXXXX--Slender wheatgrass
------XXXXXX--Sweetclover
---------------XXXXX----------XXXXX--Prickly lettuce
--------------------XXXXXXX--Many-flowered aster
Wild bean-------------------------XXXXXXXXXXXXXXXXXXXX
Missouri goldenrod---------XXX
Dock------------------------------XXXXXXXXXXXXXXXXXXXX
Cocklebur------------------------------------------XXXXXXXXXXXXXXXXXXX
Witchgrass--------------------------------------------------------XXXXXXXXXXXX
Barnyardgrass----------------------------------------------------------------XXXXXXXXXXXXX
Rice cutgrass-------------------------------------------------------------------------XXXXXXXXXXXXXXXXXXXXXXXXX
Green ash--------------------------------------------------------------------------------------------------X
```

Figure 32. Profile of transect Qo 4, West Bend Area, E1/2, Sec.14, T108N, R74W, Sept. 1971.



XXXXXXX--Western wheatgrass

-------XXXXXXXXXXX--Sweetclover

Smooth brome------XXX-----XXXXXXX

Green ash------------XXXXX

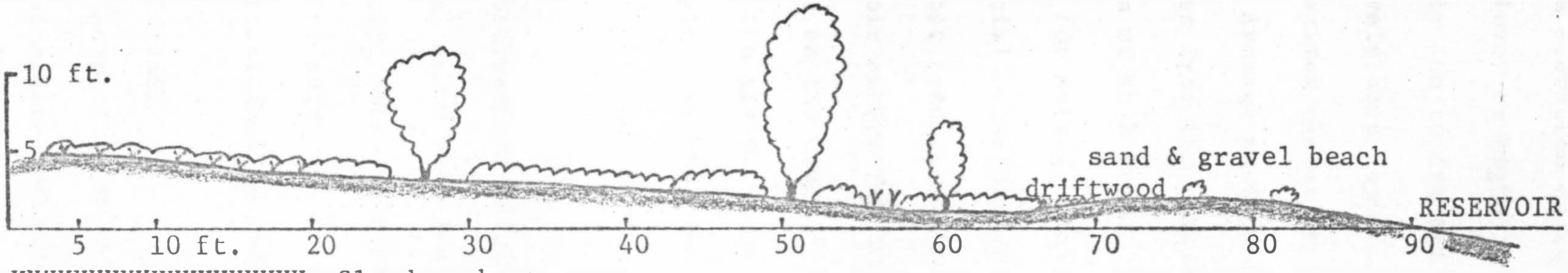
Wild rose------------------XXXX

Motherwort-----------------------XXX

Cocklebur---------------------------XXXX

Willow-------------------------------XXXXX

Figure 33. Profile of transect Qo 5, Joe Creek Area, center Sec.24, T108N, R75W, September, 1971.



XXXXXXXXXXXXXXXXXXX--Slender wheatgrass

XXXXXXXXXXXXXXXXXXXXXXXXX-----XXXXXXXXXXXXX--Sweetclover

Green ash---------------XXXXXX------------------XXXX-------X

Showy milkweed---------------XXXXXXXXXXXXX

Western snowberry--------------------------XXXXX

Beggar-ticks--XXX

Barnyardgrass--XX

Cocklebur--XXXXXXXX---------XX----XX

Giant ragweed--XXX

Figure 34. Profile of transect Qo 6, Joe Creek Area, S1/2, Sec.24, T108N, R75W, Sept. 1971.

maximum elevation calculated was 4.5 feet. The high frequency of sweetclover on higher elevations of the succession zone here is probably due to its ability to extract available ground water from relatively deep depths.

Maximum elevation of tree seedling sites ranged from 0 to 5 feet. Average maximum elevation was 200 feet. The maximum distance of trees from the reservoir ranged from 2 to 115 feet, with an average maximum of 46.8 feet. High permeability of soil is attributed as the reason for average maximum distances from the reservoir being higher on glacial outwash than on any previous parent material.

Most tree seedlings are not in danger of damage from the reservoir except for one (Figure 32). On the geological map this site is on the edge of glacial outwash. An inspection of the shoreline showed the gravel stratum to be only a few inches thick. The conclusion was that the outwash thins out at its perimeters and the abundance of herbaceous dicots was partially due to a perched water table.

Observations of planted trees on glacial outwash showed fair survival under 1440 feet above sea level or 20 feet above the reservoir. Shelterbelts planted above 1440 feet showed poor survival. Excellent survival and growth occurs in shelterbelts planted within 10 vertical feet of the reservoir (Figure 35).

<u>All transects</u>

A comparison of distances and elevations of the terrestrial succession zone and tree seedling sites on all parent materials

Figure 35. Glacial outwash shoreline, West Bend Area, September, 1971. Note condition of shelterbelt.

indicates a correlation with probable permeability (Table 5). Because of differences in slopes adjacent to the reservoir a useful index for comparing different parent material can be devised by multiplying average maximum elevations times distances. For succession zones, proceeding from shale to outwash, the indexes are 55, 118, 343 and 486. The indexes for location of tree seedlings are derived by multiplying average maximum elevations for a parent material by the average maximum distance from the reservoir. The indexes proceeding from shale to outwash are 1, 11, 68 and 94. Both sets of indexes seem to be roughly correlated with the success of prior tree plantings on their respective parent materials.

The percent of occurrence of individual plant species shows that three non-grassland plants occurred on over 55% of the transects (Table 6). Barnyardgrass was dominant on 70 percent of the transects, cocklebur on 67 percent and dock on 74 percent of the transects. All three species appear to be good indicators of favorable soil moisture and potential tree growing sites. After many observations dock seems to be more closely correlated to trees in its environmental requirements than the other two species. Dock also has a seedstock that persists over the winter and is easily identified in the spring.

Table 5. A Comparison of Elevation and Distance from the Reservoir on the Four Parent Materials.

Parent Material	Width of terrestrial succession zone Range ft.	Width of terrestrial succession zone Average ft.	Maximum elevation of terrestrial succession zone Range ft.	Maximum elevation of terrestrial succession zone Average ft.	Maximum elevation of tree seedling sites Range ft.	Maximum elevation of tree seedling sites Average ft.	Maximum distance of trees from reservoir Range ft.	Maximum distance of trees from reservoir Average ft.
Pierre Shale (Gregory Member Kpg)	17-75	42	1-2	1.3	0-1	.25	0-10	4.2
Terrace Alluvium (Qta)	45-110	79	1-3	1.5	0-1	.38	1-70	27.9
Loess (Ql)	42-115	73	.3-9	4.7	0-4	1.57	15-76	43.6
Glacial Outwash (Qo)	73-245	108	1-10	4.5	0-5	2.00	2-115	46.8
ALL TRANSECTS	17-245	75	1-10	3.0	0-5	1.08	0-115	33.0

Table 6. Dominant Vegetation found within all Transects in 1971.

Common name	Frequency % of Transects	Botanical name and Authority
Barnyardgrass	70	*Echinochloa crusgalli* (L.) Beauv.
Beggar-ticks	15	*Bidens frondosa* L.
Blue grama	4	*Bouteloua gracilis* (H.B.K.) Lag.
Buffalo bur	4	*Solanum rostratum* Dunal.
Cat-tail	33	*Typha angustifolia* L.
Cocklebur	67	*Xanthium italicum* Moretti.
Common ragweed	15	*Ambrosia elatior* L.
Common sunflower	30	*Helianthus annuus* L.
Cyperus	19	*Cyperus spp.* L.
Dock	74	*Rumex sp.* L.
Eastern cottonwood	30	*Populus deltoides* Marsh.
False indigo	4	*Amorpha fruticosa* L.
Foxtail barley	19	*Hordeum jubatum* L.
Giant ragweed	33	*Ambrosia trifida* L.
Green ash	37	*Fraxinus pennsylvanica* Marsh.
Japanese brome	15	*Bromus japonicus* Thumb.
Kochia	19	*Kochia scoparia* (L.) Schrader.
Lady's thumb	19	*Polygonum persicaria* L.
Major plantain	4	*Plantago major* L.
Many-flowered aster	15	*Aster ericoides* L.
Missouri goldenrod	4	*Solidago missouriensis* Nutt.
Motherwort	15	*Leonurus cardiaca* L.
Prairie bulrush	7	*Scirpus maritimus* L.
Prickly lettuce	7	*Lactuca virosa* L.
Prickly pear	7	*Opuntia spp.* Mill.

Table 6. (continued)

Common name	Frequency % of Transects	Botanical name and Authority
Rice cutgrass	11	Leersia oryzoides (L.) Sw.
Showy milkweed	4	Asclepias speciosa Torr.
Slender wheatgrass	67	Agropyron trachycaulum (Link.) Matte.
Smooth brome	11	Bromus inermis Leyss.
Snow-on-the-mountain	4	Euphorbia marginata Pursh.
Spike rush	4	Eleocharis spp. R. Br.
Stick-tight	7	Bidens cernua L.
Sweet clover	41	Melilotus spp. Mill.
Western snowberry	15	Symphoricarpos occidentalis Hook. Wolfberry.
Western wheatgrass	7	Agropyron smithii Rydb.
Wild bean	4	Strophostyles helvola (L.) Ell.
Wild rose	4	Rosa spp. L.
Willow	41	Salix spp. L.
Witchgrass	15	Panicum cappillare L.

CONCLUSIONS AND SUMMARY

The conditions under which natural tree seedlings occur and the extent of secondary plant succession adjacent to a semiarid grassland reservoir seem dependent on the ability of the shoreline area to absorb water. Areas with impermeable sub-soils are favorable for trees only within a few feet of the reservoir. These trees have little potential of becoming useful for recreational use because of damage from ice, storms and shore erosion. Secondary plant succession on impermeable sub-soil is limited to areas disturbed by high water. The more permeable the shoreline area the farther inland tree seedlings can be established and the greater the extent of secondary plant succession. Areas with high permeability have favorable tree growing sites well out of range of ice, storm and erosion damage. These sites have good potential for successfully growing trees for recreational use. With subirrigation the trees are relatively independent of rainfall and soil surface conditions, and can withstand heavy recreational use. Three plant species exhibited high frequency of association with natural tree seedlings. Of the three, dock is believed to have the best potential as an indicator of favorable tree growing sites.

In summary, when a floodplain forest has been inundated by a reservoir in a semiarid region, the presence of that reservoir does not assure the reestablishment of a riparian forest along the new shoreline. The potential success of a new phreatophyte forest will depend largely on the amount of water infiltration into the surrounding shoreline area and the development of protective sandbars and beaches. The extent of water infiltration and beach formation along new shorelines is directly proportional to the amount of sand and gravel sized particles in the subsoil.

LITERATURE CITED

Bird, E.C.F., 1968. Coasts. The Australian National University Press, Canberra. 246.

Chapman, V.J., 1964. Coastal vegetation. Pergamon Press Ltd., London. 245.

Chikishev, A.G., 1965. Plant indicators of soils, rocks, and subsurface waters. Consultants Bureau Enterprises, Inc., New York. 210.

Crandell, D.R., 1958. Geology of the Pierre area South Dakota, geological survey professional paper 307. U.S. Government Printing Office, Washington, D.C. 83.

Flint, R.F., 1955. Pleistocene geology of eastern South Dakota, geological survey professional paper 262. U.S. Government Printing Office, Washington, D.C. 173.

Gates, F.C., 1949. Field manual of plant ecology. McGraw-Hill Book Co., Inc., New York. 137.

George, E.J., 1953. 31-Year results in growing shelterbelts on the northern great plains. U.S. Dept. Agr. Cir. 924.

Goor, A.Y., and C.W. Barney, 1968. Forest tree planting in arid zones. The Ronald Press Co., New York. 409.

Iowa State Highway Com., 1916. Iowa lake bed survey report. Des Moines. 250.

Johnson, D.W., 1919. Shore processes and shoreline development. John Wiley & Sons, Inc., New York. 584.

Kuchler, A.W., 1964. Potential natural vegetation of the conterminous United States. American Geographical Society, New York. 116.

Oosting, H.J., 1956. The study of plant communities. second ed. W.H. Freeman and Co., San Francisco. 440

Russell, R.J., 1967. River plains and sea coasts. University of California Press, Berkeley and Los Angeles. 173.

Sauer, J., 1967. Geographic reconnaissance of seashore vegetation along the Mexican gulf coast. Louisiana State University Press, Baton Rouge. 59.

S.D. Ag. Exp. Sta., 1971. Climate of South Dakota. S.D. Ag. Exp. Sta. Bull. 582. n.p.

S.D. State Geological Survey., 1950 a. Areal geology of the Lower Brule quadrangle. Vermillion, S.D. Map, 1 sheet.

S.D. State Geological Survey., 1950 b. Areal geology, Fort George Butte quadrangle. Vermillion, S.D. Map, 1 sheet.

S.D. State Geological Survey., 1951 a. Areal geology of the De Grey quadrangle. Vermillion, S.D. Map, 1 sheet.

S.D. State Geological Survey, 1951 b. Areal geology of the Stephan quadrangle. Vermillion, S.D. Map, 1 sheet.

Smith, N., 1971. A history of dams. Peter Davies, London. 279.

Spurr, S.H., 1964. Forest ecology. The Ronald Press, New York. 352.

Stoeckeler, J.H., 1970. The United States of America, p. 268 to 346. In R.N. Kaul [ed.] Afforestation in arid zones. Dr. W. Junk N.V. Publishers, The Hague.

U.S. Dept. of Agriculture, 1941. Climate and man. The Yearbook of Agriculture. U.S. Government Printing Office, Washington, D.C. 1248.

U.S. Department of Agriculture, 1955. Water, The Yearbook of Agriculture. U.S. Government Printing Office, Washington, D.C. 751.

Veatch, J.O. and C.R. Humphrys., 1964. Lake terminology. Michigan Ag. Exp. Sta. Bull. 14. 271.

APPENDIX

RECOMMENDATIONS FOR RESERVOIR FOREST MANAGEMENT

The ultimate use of a tree planting should be determined before field operations begin. On a reservoir in a semiarid climate, the use should determine where the trees are planted and how they are maintained. Tree plantings for recreational use, (picnicing and camping) should either be irrigated or located on a site with available ground water. To stay healthy under the impact of human use they will need more moisture than what ordinarily falls as rain.

Tree plantings for non-recreational use, (wildlife, wind abatement or screening) that are not irrigated and are located beyond available ground water should be designed for maximum water conservation. Dense low growing shrubs should be planted on all sides to divert drying winds and to catch snow. Plant competition should be controlled until after the crowns have adequately shaded the ground.

Natural tree germination and growth along the shorelines can be encouraged by minimizing lake level fluctuation and discouraging mowing and stock grazing near the reservoir. Successional development of forest along the reservoir might be accelerated by planting phreatophyte trees on sites showing active invasion of grassland vegetation by more mesic species. On sites too far above the ground water for initial benefit to the seedlings, water conservation practices may be necessary until the seedling roots can reach the ground water. Tree seedlings on potential recreation sites should be protected from beaver damage. Wire screens or other rodent proof devices may be feasible.

Trial plantings should be made on sites containing possible indicator species like dock to evaluate their reliability.

Research would be desirable on the feasibility of constructing water concentrating facilities like terraces, small dams and micro-watershed to create favorable conditions for tree growth.

Heavy soils like those derived from Pierre shale should be avoided when planning tree plantings. Research on the feasibility of artificially creating water infiltration routes from the reservoir into these soils may increase their tree growing potential.

The handplanting of phreatophytic seedlings and cuttings along the reservoir should be evaluated as a possible means of forest establishment.